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ABSTRACT RELATED TO THE DAMAGE TOLERANCE OF BONDED COMPOSITE STRUCTURES

Part 1
Evaluation of Bonded Lap Joints with Variable Thickness Adhesive Layers

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With the intent of developing a substantial background for the research study of variable thickness bondline effects using approximate analytical and numerical methods, and an experimental series of single lap, and double lap configurations, a range of tests based on uniform thickness bondlines have been considered. The experimental sequence of single lap joints resembles that of the widely used ASTM D1002 specimens but with thinner titanium and carbon fiber composite adherends. For a range of bondline thicknesses from 0.003 inch up to 0.035 inch the variation of average lap shear strength are shown to vary between 3,400 psi and 4,700 psi. The majority of specimens comprised adherends approximately 0.038 inch thick (titanium and composite) and an epoxy-based paste adhesive DP460 obtained from 3M.

Subsequently, varying bondline thickness specimens, with respect to both width and length, have comprised the latest sequence of experiments and these results will be presented. Surface failure morphologies will be discussed in addition to the experimental strength data together with predictions of shear and peel stress distributions.

Part 2
Strain-Based Nonlinear Failure Prediction of Adhesively Bonded Composite Lap Joints

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The capability to predict the development of plastic strain in the adhesive layer of bonded joints allows the design of joints than can carry significantly higher load than that predicted by elastic-limit-based analysis. However, to safely design joints in the plastic regime, a thorough understanding of the joint's mechanics, and how the important parameters govern its behavior is necessary. A theoretical model predicting the plastic strain in bonded joints subject to in-plane shear load has been developed. This model predicts failure loads that are three to four times greater than elastic-limit-based failure criteria. Comparison of the theoretical model predictions with nonlinear finite element predictions shows the theoretical model to be most accurate for joints having thin bondlines of up to 0.01 in. thickness. The extension of this model to track plastic strain in multiaxially-loaded joints, e.g., simultaneous tension and in-plane shear, is underway.